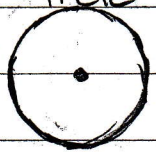
The Story of Newton & Gravity

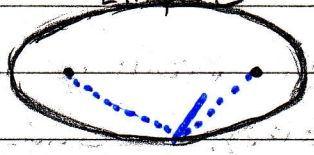
- After the work of Galileo & Kepler - it was known that the planets move about the Sun in special ~~ovals~~ ovals known as ellipses:

Circle



has One focus pt.

Ellipse



has two focus pts

- The shape was known, but the reason was not. No one could figure out what was keeping the moon around (E), and the planets around the Sun, until Newton came along.

- Early in his career, Isaac Newton, after observing a falling apple - or being hit in the head by one as legend goes, reasoned that the same force that makes the apple fall also keeps the moon in orbit.

- Newton soon determined the elliptical shapes of orbits for himself, and named the invisible force - gravitation.

- It was not known that Newton had

come to an understanding of these concepts until Edmond Halley made an inquiry of Newton in 1684 concerning the shape of orbiting planets.

- Newton provided his explanation and, pushed by Halley, eventually produced his great work - the greatest contribution to modern physics - "Mathematical Principles of Natural Philosophy" or "The Principia".

- The 3 volume book centered on Newton's 3 laws of motion and his universal law of gravitation.

- Newtons Laws:

#1 - An object at rest tends to stay at rest and an object in motion tends to stay in motion unless acted upon by a force.

* Hockey puck on ice

#2 - The acceleration of an object is directly (and in the same direction) proportional to the force applied and inversely proportional to the objects mass.

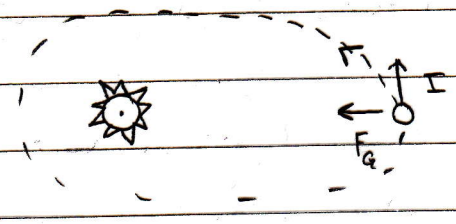
* Bowling ball vs Beach ball

$$F = ma \; ; \; \boxed{a = \frac{F}{m}} \; ; \; m = \frac{F}{a}$$

*Skateboard #3- For every action, there is an equal and opposite reaction.

The Universal Law of Gravitation

- Was a unification of the "celestial" and the "terrestrial".
- Hard to believe b/c it was an example of action at a distance.
- The Law States: All matter in the universe attracts all other matter in the universe w/ a force that is directly proportional to mass and inversely proportional to distance squared.
  - directly proportional: ||
  - inversely proportional: |—
  - $F_g \propto M$ & $F_g \propto \frac{1}{d^2}$
  - All matter pulls on all other matter and the strength of the pull depends on the masses of the objects and how far apart they are.
  - The more massive the objects, the stronger the pull and vice versa
  - The closer the objects, the stronger the pull and vice versa (inverse square law)



The Formula:

$$F_G = -\frac{GMm}{r^2}$$

where; *disregard units

- $G = 6.67 \times 10^{-11}\ N(m/kg)^2$
- M, m = mass (kg)
- r = distance (m)

* negative sign implies directional element of Force vector - attractive.

- Newton's work enabled us to understand and predict the motions of the universe using mathematics, making Space travel possible.

- Newton could only describe and measure the effects of F_G, he could not define it.

- A more substantial understanding of F_G was achieved by Albert Einstein in the 20th Century.
  - Einstein said that gravity is the curvature of spacetime caused by the presence of a mass - General Relativity

- According to Newton's 3rd law of motion, two objects will pull on each other w/ an equal amount of force. But if the masses are very different, only one object will move; this is why when we jump up, the (E) doesn't "fall up" to our feet, we accelerate towards the (E).

- Weight is a measure of the force of gravity acting on an object, and changes as your position in the universe changes.

- The force of gravity (F_G) is measured in Newtons (N) - a unit of force like lbs. or Ft. lbs. of torque. (1 N = the net force required to accelerate a mass of 1kg at a rate of $1 m/s^2$)

- Newton proved that the combination of a planet's inertia (tendency to move in a straight line) and the force of gravity from the Sun results in the elliptical orbits of the planets.